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Mangrove forest age as a predictor of overwintering habitat quality for migratory songbirds

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Mangrove forest age as a predictor of overwintering habitat quality for Neotropical migratory songbirds

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Introduction

Wetland ecosystems are critical habitats for a host of organisms including resident and migratory birds. Forested wetlands (i.e., mangroves) surrounding Panama City, Panama are currently being drained and cleared to allow for commercial and residential development. Restoration or replacement of mangroves (i.e. younger stands) may not be a sufficient surrogate for existing mature stands. **There is a paucity of information on how mangrove age may affect overwintering neo-tropical migratory birds dependent on these habitats. Identifying high quality overwintering habitats is critical to supporting healthy breeding populations.**

Carotenoid-pigmented feathers are an honest indicator of the overall health and condition of a bird because carotenoids are critical to immune function, vitamin synthesis, and many vital cellular processes. If a bird is able to allocate these important molecules towardsfeather coloration, this can be an honest signal of health/condition with more rich yellow color indicating a bird is in better condition than a paler yellow color. Feather carotenoid content has a positive relationship with nesting success in Virginia Prothonotary Warbler populations (Fig. 1a,b). Carotenoid pigments are only deposited in feathers during molt, on the breeding grounds in this species (Fig 1c).

Objectives

To determine if mature mangrove forests provided higher quality habitat to (wintering) birds compared with younger mangroves, we compared the following in mangroves of mature, intermediate, and young age:

1) Feather reflectance (specifically carotenoid content) of Prothonotary warblers.
2) Body condition of Prothonotary warblers and Northern waterthrush.

Methods

Feather Reflectance

Reflectance signatures were obtained from breast feathers by a JAZ-PX spectrophotometer with a pulsed-xenon light source (Ocean Optics). Spectra were quantified using standard color variables which provide an objective measure of color comparable between individuals. Violet-blue (VB) chroma is the proportion of reflectance in the violet-blue region of the spectrum relative to reflectance over the entire spectrum *(Eq1).* Because carotenoid pigments maximally absorb in the violet-blue region (i.e., 400-515nm)(Fig.2) this variable serves as a relative measure of carotenoid concentration in the feather sample. Note VB chroma is negatively related to carotenoid concentration, such that lower values indicate higher carotenoid content.

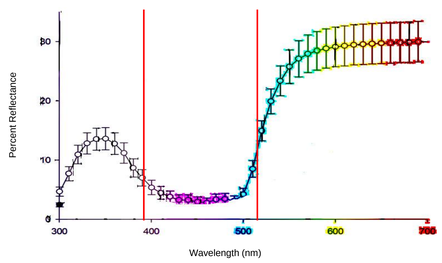

Fig.2. Typical spectral signature of carotenoid-pigmented Prothonotary warbler breast feathers (mean ±SE, n=69).

$$Eq\ 1{:}\ VB\ Chroma = \frac{Sum(400nm - 515nm)}{Sum(300nm - 700nm)}$$

Body Condition Index

Calculated as residuals from a linear regression of body mass versus wing chord length. Positive values indicate individuals in relatively good condition where negative values indicate individuals in relatively poor condition.

Mangrove Study Sites in Panama

Age classes of mangrove sites:

- **Young** (Panama Viejo)
- **Intermediate** (Playa Bonita)
- **Mature** (Juan Diaz).

Relative age classes were assigned based on historical satellite imagery (Google Earth) and quantitative measures of understory vegetation density (Table 1).

Table 1. Site age and understory composition

	Panama Viejo	Playa Bonita	Juan Diaz
Approximate age	<10 years	10-15 years	>40 years
Water cover %(S.E.)	10 (11.24)	22.9 (11.24)	52.0 (11.2)
Woody Vegetation <1m %(S.E.)	21.5 (6.96)	50.8 (6.36)	11.0 (7.9)

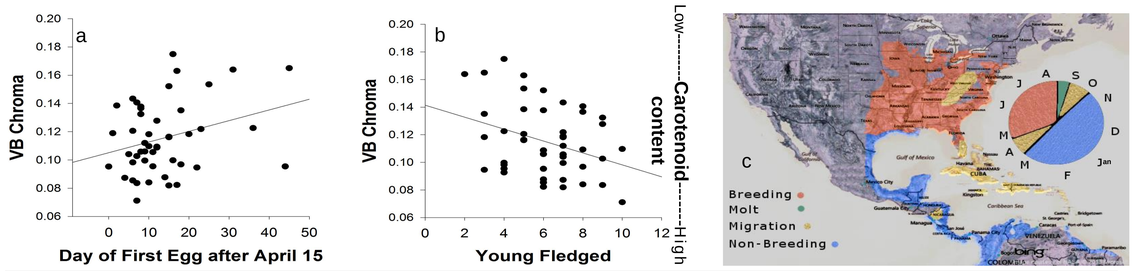

Fig. 1. Relationship between carotenoid-pigmented feather reflectance and reproductive success of female Prothonotary Warblers in Virginia (Bulluck and Kay, unpublished data)**.** Females with higher feather carotenoid content **a)** laid their eggs earlier (R^2=0.086 *p*=0.039) and **b)** fledged more young than females with lower feather carotenoid content *(*R^2=0.11 *p*=0.007). **C)** Location and timing of annual cycle events of Prothonotary warbler (Range data: Natureserve 2007).

Results

Prothonotary Warbler Feather Reflectance

- Mean VB chroma differed between sex and age classifications with males and older birds having higher carotenoid content than females and younger birds (*p* = 0.010 and *p* = 0.0215, respectively).
- After accounting for these differences in our model, breast feathers from Prothonotary Warblers in young mangrove stands had lower carotenoid content than feathers from warblers occupying older mangrove stands (*p* = 0.0047, Fig 3a).

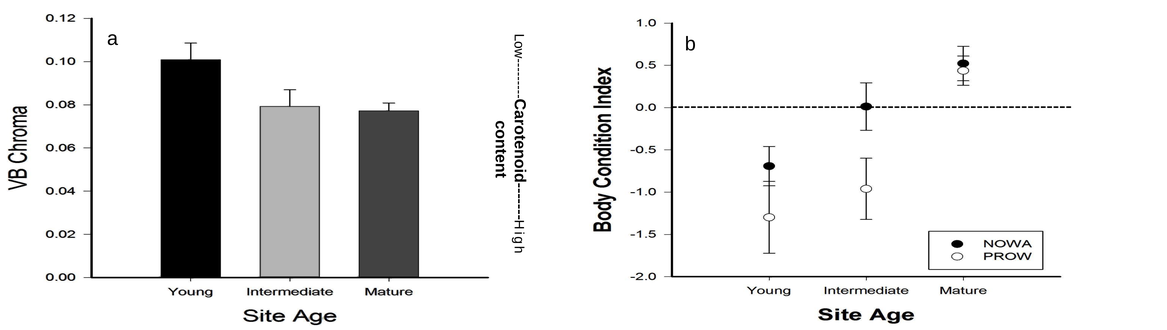

Fig. 3. Mangrove site comparisons of **a**) mean VB chroma of Prothonotary Warbler breast feathers and **b**) body condition index of Northern Waterthrush (NOWA) and Prothonotary Warbler (PROW).

Body Condition Index

Body condition index differed among sites for both Prothonotary warblers and Northern waterthrush (Fig.3b). Pairwise comparisons of sites indicate birds that occupy the mature mangrove stand were in better body condition than birds from younger sites (Table 2).

Table 2. Pairwise site comparisons of NOWA and PROW body condition and VB Chroma of PROW

	Young (vs. Intermediate)	Intermediate (vs. Mature)	Mature (vs. Young)
NOWA Body Condition Mean, S.E. (Test Statistic, *p*-value)	-0.57 ±0.192 (F= 3.4, 0.067)	-0.07 ±0.186 (F=3.07, 0.081)	0.32 ±0.135 (F=14.6, **0.0002***)
PROW Body Condition Mean, S.E. (Test Statistic, *p*-value)	-1.29 ±0.42 (F=0.365, 0.548)	-0.96 ±0.36 (F=12.11, **0.0009***)	0.43 ±0.173 (F=14.31, **0.0003***)
PROW VB Chroma Mean, S.E. (Test Statistic, *p*-value)	0.10 ±0.01 (χ^2=4.193, **0.04***)	0.079 ±0.008 (χ^2=0.063, 0.80)	0.07 ±0.008 (χ^2=7.98, **0.0047***)

Conclusions

- Other studies show that birds with higher carotenoid concentrations in their feathers tend to hold higher-quality wintering territories, leave wintering grounds sooner, and arrive on breeding grounds earlier than those with lower concentrations.
- Breast feathers of Prothonotary Warblers from our mature mangrove site had significantly greater carotenoid content than from our youngest site suggesting that wintering Prothonotary Warblers in mature sites may arrive earlier and/or outcompete conspecifics.
- Body condition of birds occupying our mature site was significantly better than both the intermediate- and younger-age mangrove sites.
- Measures of body condition can be considered a short term indicator of individual performance and reflect the abundance of resources available in a particular environment.
- Mature mangrove stands may provide higher quality habitat to wintering birds. More data are needed on resource availability in mangroves of differing ages to more thoroughly understand this relationship.

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